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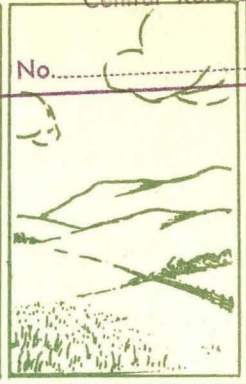
FOREST RESEARCH NOTES

U.S.DEPARTMENT OF AGRICULTURE
FOREST SERVICE
CALIFORNIA FOREST AND RANGE
EXPERIMENT STATION *

STEPHEN N. WYCKOFF, Director



No. 66 February 6, 1950

BOARD-FOOT AND CUBIC-FOOT VOLUME TABLES FOR SECOND-GROWTH REDWOOD

By A. A. Hasel 1/
Forest Survey, Division of Forest Economics

The tables presented here are for use in estimating the volume of second-growth redwood trees: board-foot volume by the Scribner and International 1/4" rules, cubic volume in the sawlog portion, and cubic volume to a 4" top diameter. The tables were prepared in connection with the forest survey of California, which is being conducted as part of the nation-wide Forest Survey Project.

Since the tables by Bruce and Schumacher 2/ were prepared, sufficient time has elapsed to provide larger trees for measurement. The volumes given here for sawlog-size trees are based on measurements on 118 trees, of which 70 represent new data mainly in the larger size classes. The largest tree measured was 60 inches d.b.h., and the tables extend through this diameter class. For second-growth trees larger than 60 inches d.b.h. it is likely that existing old-growth tables will apply satisfactorily. Data for trees of less than sawlog size were randomly selected from Forest Service data collected in 1899. All data were collected in Del Norte, Humboldt, Mendocino, and Sonoma Counties. The top utilization for the sawlog portion of the trees was determined from a survey of utilization practices on Forest Service sales (fig. 3) in other timber types, since an adequate sample of practice in second-growth redwood was not available.

1/ Grateful acknowledgment is made of assistance given by other members of the Division of Forest Economics, including Miss A. E. Rae for computations, K. Schoenlank for compilation of volumes, and E. M. Hornibrook for helpful advice.

2/ 1925. Bruce, Donald, and Francis X. Schumacher. Revised Volume Tables for Second-growth Redwood. Jour. Forestry 23: 148-155.

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Procedure

Tree measurements were plotted on Forest Service Tree Measurement Form 558a (Rev. November 1928) and cubic volumes were obtained by planimetering. Board-foot volumes were obtained by scaling in 16-foot lengths, allowing 0.3-foot for trim. Additional top sections and small trees were scaled as 8-foot logs or fractions of 8-foot logs. Diameters at the small end were read to 0.1-inch on Form 558a, and the scale was determined from the following formulas:

16-foot logs

Scribner volume = $0.79\ D^2 - 2D - 4$
International 1/4" volume = $0.796\ D^2 - 1.375D - 1.230$

8-foot logs

Scribner volume = $0.395\ D^2 - D - 2$
International 1/4" volume = $(0.44\ D^2 - 1.2D - 0.3)\ 0.904762$

The volume tables are based on the relationship of volume to diameter, height, and the Girard form class, which may be defined as d.i.b. at the small end of the butt 16-foot log expressed as a percentage of d.b.h. o.b.

Converting Factors

The volumes are tabulated for Form Class 70, which is average for the data, but factors are given for converting volumes to other form classes. The tables can therefore be readily adapted or localized to particular stands, or types of trees in the stand, by determining the form class of the particular stand to be cruised. Determination of form class on 50 trees, well distributed throughout the range of diameters and over the area, should be satisfactory for this purpose. If form class does not vary with diameter, the stand average may be used.

Heights to tip and to 4-, 8-, 10-, and 12-inch i.b. top diameters are curved over d.b.h. in Figure 1. These curves indicate average taper in the tops and therefore provide a guide to converting heights from one top diameter basis to another. Together with the curve of merchantable length in Figure 2, they make it possible to adjust the total cubic table to larger top diameters, or to approximate the board-foot volumes on a fixed top diameter basis.

Growth and Form-class Determinations

The bark thickness curves in Figures 4, 5, and 6 are useful in connection with growth studies and form-class determination.

Example of growth determination:

(1) Tree 30.0 in. d.b.h., 5 logs, present volume 1000 b.f. Scribner. Increment core shows 1.5" radial growth past 10 years.

(2) Fig. 4 indicates bark thickness now 4.8". Then, 30.0 - 4.8 - 2(1.5) = 22.2 in. d.i.b. ten years ago.

(3) Fig. 6 indicates bark thickness of 4.2 in. 10 years ago, so 22.2 + 4.2 = 26.4 in. d.b.h. 10 years ago.

(4) Assume curve of height-diameter relationship indicates height of 4 logs to merchantable top for tree 26.4 in. d.b.h. From Table 1, volume 10 years ago is 615 + (710-615) 1/5 = 634 b.f.

(5) Growth during past 10 years was 1000 - 634 = 366 board feet.

Example of form class determination:

(1) D.B.H. of tree is 30.0 in. o.b.

(2) Determine location of top of first 16-foot log (1.5' stump on uphill side plus 16.0' log plus 0.3' trim): 17.8 ft. above ground.

(3) Carefully estimate average taper from b.h. to top of first log by use of plumb bob. Best to do this from uphill side of tree so that eye is about level with point midway between b.h. and top of log. Average one-side taper estimated to be 3.0 in.

(4) Then, 30.0 - 2(3.0) = 24.0 in. o.b. top first log. From Fig. 5, bark thickness is 3.0 in.

$$\frac{24.0 - 3.0}{30.0} \times 100 = 70 = \text{form class.}$$

The curve of form class over d.b.h., for all the data used is shown in Fig. 7. The average of all trees was very close to 70.

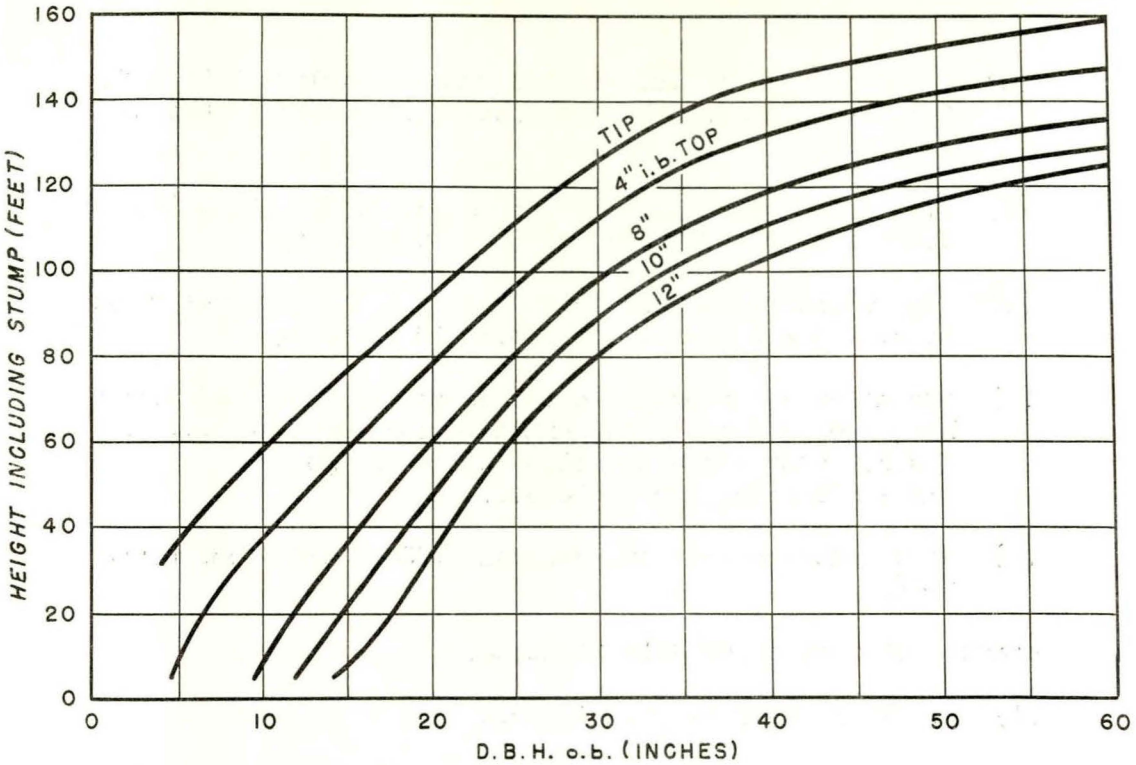

Fig.1 — Height to tip and to fixed top of 4, 8, 10, and 12 inches, by d.b.h. Based on 145 trees used in preparing the volume tables.

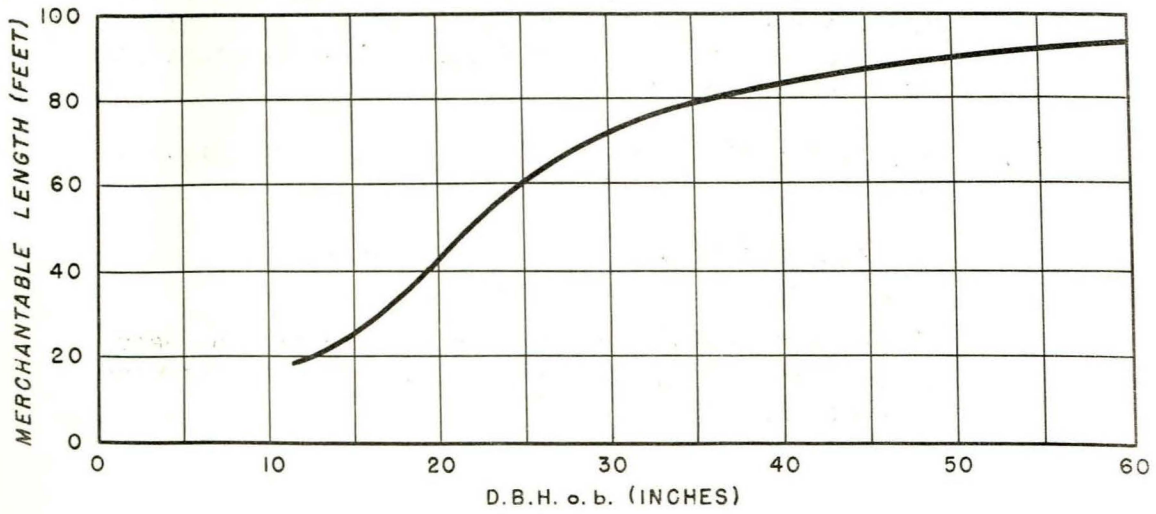

Fig.2 — Merchantable length by d.b.h. Based on 118 trees use in preparing the volume tables.

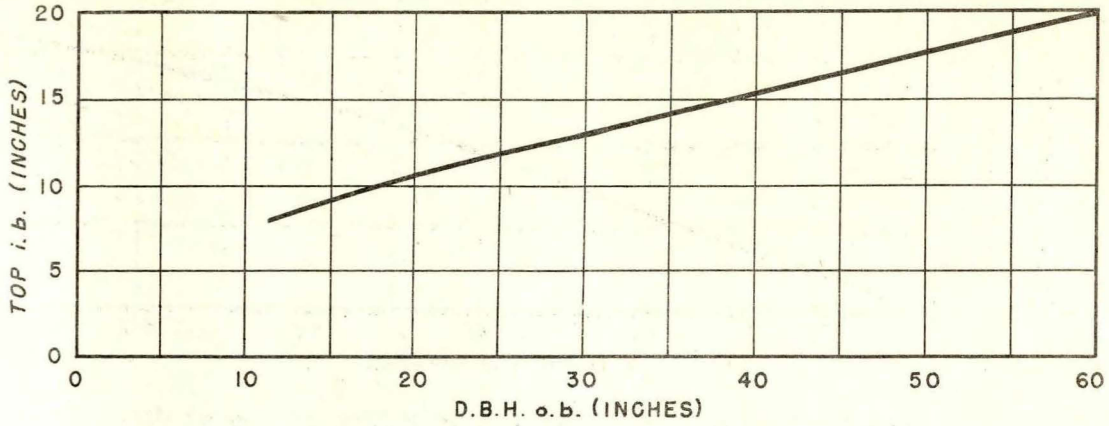

Fig. 3 — Top utilization by d.b.h. classes. (Based on Forest Service data for other species, 1945)

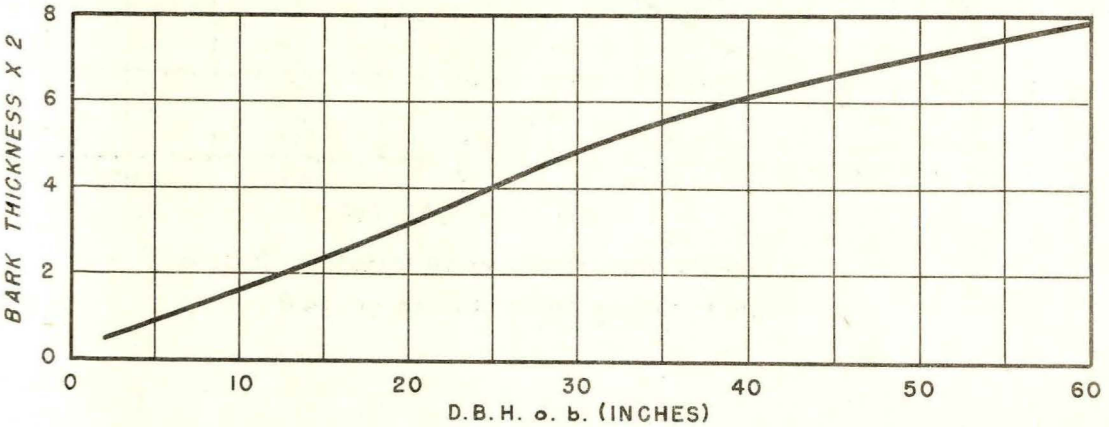

Fig. 4 — Double bark thickness in inches at B.H. by d.b.h. outside bark. (Based on 149 trees)

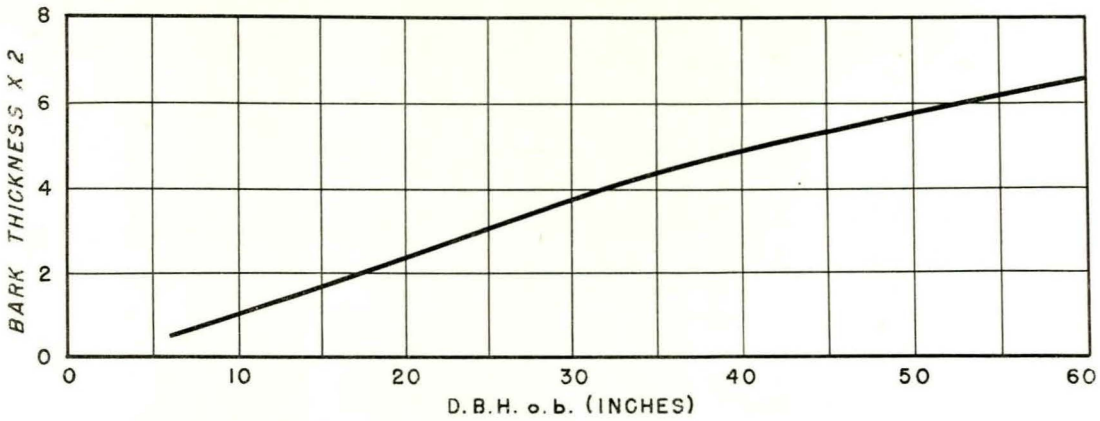

Fig.5 — Double bark thickness in inches at top of first 16-foot log by d.b.h. (Based on 149 trees)

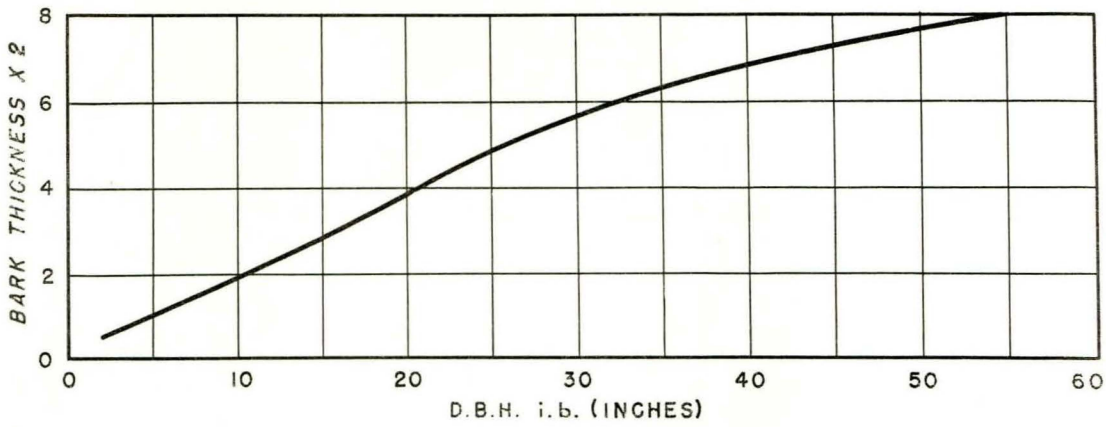

Fig.6 — Double bark thickness in inches at B.H. by d.b.h. inside bark. (Based on 149 trees)

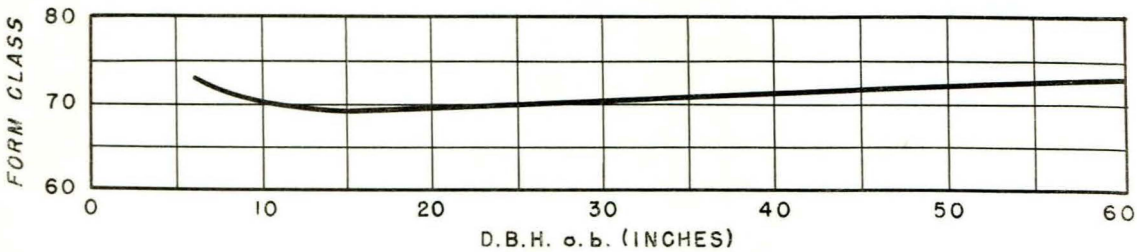

Fig.7 — Form class by d.b.h. (Based on 150 trees)

Table 1.- Form-class Volume Table for Second-growth Redwood

BOARD FEET - SCRIBNER RULE

Form Class 70

D.B.H.: in inches:	Height in number of 16.3-foot logs utilized										Minimum top d.i.b. utilized	Basis No. of trees
	1	2	3	4	5	6	7	8	9	10		
12	37	72	105								8	9
14	50	97	142								9	13
16	65	125	183	240							10	17
18	82	157	230	302	372						10	9
20	101	193	282	370	456	541					11	8
22	121	232	340	445	549	651					11	6
24	143	275	402	526	649	770	890				12	4
26		321	469	615	758	900	1040				12	8
28		370	542	710	875	1038	1200	1360			13	10
30		423	619	811	1000	1187	1372	1555			13	3
32		479	701	919	1133	1345	1554	1762			14	6
34		539	789	1033	1274	1512	1748	1981			14	8
36		602	881	1154	1423	1689	1952	2213	2472	2729	15	4
38		668	978	1282	1580	1875	2168	2457	2745	3030	15	4
40		738	1080	1415	1745	2071	2394	2714	3031	3346	15	2
42			1187	1556	1918	2276	2631	2983	3331	3678	16	1
44			1299	1702	2099	2491	2879	3264	3645	4025	16	3
46			1416	1855	2288	2715	3138	3557	3973	4386	17	1
48				2014	2484	2948	3407	3863	4314	4763	17	1
50				2180	2688	3190	3687	4180	4669	5155	18	-
52				2352	2900	3442	3978	4510	5037	5561	18	-
54				2530	3120	3703	4280	4852	5419	5983	18	-
56				2715	3348	3973	4592	5206	5815	6419	19	-
58				2906	3583	4253	4915	5572	6223	6871	19	-
60				3103	3826	4541	5248	5950	6646	7337	20	1
Trees	22	33	12	25	17	8	1	-	-	-		118

Stump height 18" on uphill side.

Block indicates extent of basic data.

Form Class: Diameter inside bark at top of first 16.3-foot log divided by diameter outside bark at breast height, the result being multiplied by 100. Table above is for the average Form Class of the sample trees. Factors in the tabulation on the reverse side are to be used to get volumes for other Form Classes.

The equations from which the tabled volumes were obtained are as follows:

Logarithm b.f. vol. = 1.936,011 (logarithm d.b.h. in inches) + 0.939,164 (logarithm utilized length in feet) + 0.009,961 (form class) - 2.351,894.

Average deviation of individual tree volumes from values estimated by the equation is 3.9 percent.

Aggregate difference: Estimated values 0.19 percent low.

MULTIPLIERS FOR OTHER FORM CLASSES

Form class is 100 times d.i.b. top first log divided by d.b.h. o.b. Factors by which to multiply volumes in Form Class 70 table to obtain volumes for other form classes:

Form Class (Tens)	(Units) 0	1	2	3	4	5	6	7	8	9
5	0.63	0.65	0.66	0.68	0.69	0.71	0.73	0.74	0.76	0.78
6	0.80	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.96	0.98
7	1.00	1.02	1.05	1.07	1.10	1.12	1.15	1.17	1.20	1.23
8	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.48	1.51	1.55

Example: Volume of 36", 5-log tree of form class 78 is 1423 x 1.20 = 1708.

Prepared by:
Division of Forest Economics
California Forest and Range Experiment Station
Forest Service, U. S. Department of Agriculture

A. A. Hasel
February 1950

Additional copies of this table may be obtained from the California Forest and Range Experiment Station, Box 245, Berkeley 1, California.

Table 2. - Form-class Volume Table for Second-growth Redwood

BOARD FEET - INTERNATIONAL 1/4-INCH RULE

Form Class 70

D.B.H.: in inches:	Height in number of 16.3-foot logs utilized										Minimum top d.i.b. utilized	Basis No. of trees
	1	2	3	4	5	6	7	8	9	10		
12	44	83	122								8	9
14	58	111	162								9	13
16	74	142	208	272							10	17
18	92	177	258	339	418						10	9
20	112	215	314	411	507	602					11	8
22	133	256	374	491	605	718					11	6
24	157	301	440	576	711	843	975				12	4
26		348	510	668	824	978	1130				12	8
28		400	585	766	945	1121	1296	1469			13	10
30		454	664	870	1073	1274	1472	1669			13	3
32		512	749	981	1209	1435	1659	1880			14	6
34		572	837	1097	1353	1605	1855	2103			14	8
36		636	931	1219	1504	1784	2062	2338	2611	2883	15	4
38		703	1028	1347	1662	1972	2279	2583	2885	3186	15	4
40		773	1131	1481	1827	2168	2506	2840	3172	3502	15	2
42			1237	1621	1999	2372	2742	3108	3472	3833	16	1
44			1349	1767	2179	2586	2988	3387	3784	4177	16	3
46			1464	1918	2365	2807	3244	3677	4108	4535	17	1
48				2075	2559	3037	3510	3978	4444	4906	17	1
50				2238	2759	3275	3785	4290	4792	5290	18	-
52				2406	2967	3521	4069	4613	5152	5688	18	-
54				2580	3181	3775	4363	4946	5525	6099	18	-
56				2759	3402	4038	4667	5290	5909	6523	19	-
58				2944	3630	4308	4979	5645	6305	6960	19	-
60				3135	3865	4587	5301	6010	6712	7413	20	1
Trees	22	33	12	25	17	8	1	-	-	-		118

Stump height 18" on uphill side.

Block indicates extent of basic data.

Form Class: Diameter inside bark at top of first 16.3-foot log divided by diameter outside bark at breast height, the result being multiplied by 100. Table above is for the average Form Class of the sample trees. Factors in the tabulation on the reverse side are to be used to get volumes for other Form Classes.

The equations from which the tabled volumes were obtained are as follows:

Logarithm b.f. vol. = 1.848,446 (logarithm d.b.h. in inches) + 0.939,005 (logarithm utilized length in feet) + 0.009,548 (form class) - 2.162,583.

Average deviation of individual tree volumes from values estimated by the equation is 3.0 percent

Aggregate difference: Estimated values 0.19 percent low.

MULTIPLIERS FOR OTHER FORM CLASSES

Form class is 100 times d.i.b. top first log divided by d.b.h. o.b. Factors by which to multiply volumes in Form Class 70 table to obtain volumes for other form classes:

Form Class (Tens)	(Units) 0	1	2	3	4	5	6	7	8	9
5	0.64	0.66	0.67	0.69	0.70	0.72	0.74	0.75	0.77	0.79
6	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98
7	1.00	1.02	1.04	1.07	1.09	1.12	1.14	1.17	1.19	1.22
8	1.25	1.27	1.30	1.33	1.36	1.39	1.42	1.45	1.49	1.52

Example: Volume of 36", 5-log tree of form class 78 is 1504 x 1.19 = 1790.

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Forest Service, U. S. Department of Agriculture

A. A. Hasel
February 1950

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Table 3.- Form-class Volume Table for Second-growth Redwood

CUBIC FEET IN SAWLOG PORTION

Form Class 70

D.B.H. in inches:	Height in number of 16.3-foot logs utilized										Minimum top d.i.b.	Basis No. of trees
	1	2	3	4	5	6	7	8	9	10	utilized	
12	8.1	13.4	18.7								8	9
14	10.8	17.9	25.0								9	13
16	13.9	23.1	32.2	40.1							10	17
18	17.3	28.8	40.2	50.1	59.4						10	9
20	21.1	35.1	49.0	61.1	72.4	83.3					11	8
22	25.2	42.0	58.6	73.0	86.7	99.7					11	6
24	29.7	49.4	69.0	86.0	102.	117.	132.				12	4
26		57.4	80.2	100.	119.	136.	154.				12	8
28		66.0	92.2	115.	136.	157.	177.	196.			13	10
30		75.2	105.	131.	155.	179.	201.	223			13	3
32		84.9	119.	148.	175.	202.	227.	251.			14	6
34		95.1	133.	166.	196.	226.	254.	282.			14	8
36		106.	148.	184.	219.	252.	283.	314.	343.	372.	15	4
38		117.	164.	204.	242.	279.	313.	347.	380.	412.	15	4
40		129.	180.	225.	267.	307.	345.	382.	419.	454.	15	2
42			198.	246.	292.	336.	378.	419.	459.	497.	16	1
44			216.	269.	319.	367.	413.	458.	501.	543.	16	3
46			234.	292.	347.	399.	449.	497.	544.	590.	17	1
48				317.	376.	432.	486.	539.	590.	639.	17	1
50				342.	406.	467.	525.	582.	637.	690.	18	-
52				368.	437.	502.	565.	626.	686.	743.	18	-
54				395.	469.	539.	607.	672.	736.	798.	18	-
56				423.	502.	578.	650.	720.	788.	854.	19	-
58				452.	536.	617.	694.	769.	842.	913.	19	-
60				482.	572.	658.	740.	820.	897.	973.	20	1
Trees	22	33	12	25	17	8	1	-	-	-		118

Volume excluding bark.

Stump height 18" on uphill side.

Block indicates extent of basic data.

Form Class: Diameter inside bark at top of first 16.3-foot log divided by diameter outside bark at breast height, the result being multiplied by 100. Table above is for the average Form Class of the sample trees. Factors in the tabulation on the reverse side are to be used to get volumes for other Form Classes.

The equations from which the tabled volumes were obtained are as follows: Logarithm cubic volume sawlog portion = 1.880,403 (logarithm d.b.h. in inches) + 0.766,659 (logarithm utilized length in feet) + 0.008,545 (form class) - 2.649,799.

Average deviation of individual tree volumes from values estimated by the equation is 3.5 percent.

Aggregate difference: Estimated values 0.10 percent low.

MULTIPLIERS FOR OTHER FORM CLASSES

Form class is 100 times d.i.b. top first log divided by d.b.h. o.b. Factors by which to multiply volumes in Form Class 70 table to obtain volumes for other form classes:

Form Class (Tens)	(Units) 0	1	2	3	4	5	6	7	8	9
5	0.67	0.69	0.70	0.72	0.73	0.74	0.76	0.77	0.79	0.81
6	0.82	0.84	0.85	0.87	0.89	0.91	0.92	0.94	0.96	0.98
7	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17	1.19
8	1.22	1.24	1.27	1.29	1.32	1.34	1.37	1.40	1.42	1.45

Example: Volume of 36", 5-log tree of form class 78 is 219 x 1.17 = 256.

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Forest Service, U. S. Department of Agriculture

A. A. Hasel
February 1950

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Table 4.- Form-class Volume Table for Second-growth Redwood
CUBIC FEET INSIDE BARK FROM TOP OF STUMP TO A 4-INCH I.B. TOP
Form Class 70

D.B.H.: in : inches:	Height in feet from ground on uphill side to tip																	: Basis : No. of : trees
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	
6	2.5	2.9	3.3	3.6														6
8	4.5	5.2	5.9	6.6	7.2													10
10	7.1	8.3	9.4	10.5	11.5	12.5												9
12	10.4	12.2	13.8	15.3	16.8	18.2	19.6											11
14	14.4	16.7	19.0	21.1	23.2	25.1	27.0											13
16	19.0	22.1	25.1	27.9	30.6	33.2	35.7											17
18		28.3	32.1	35.7	39.1	42.4	45.6	48.7	51.8									9
20		35.2	39.9	44.4	48.7	52.8	56.8	60.7	64.4	68.1	71.7	75.2						8
22		42.9	48.7	54.1	59.4	64.4	69.3	74.0	78.6	83.0	87.4	91.7	95.9					6
24		51.4	58.3	64.9	71.2	77.2	83.0	88.7	94.2	99.5	105.	110.	115.					4
26			68.9	76.6	84.1	91.2	98.1	105.	111.	118.	124.	130.	136.					8
28			80.4	89.4	98.1	106.	114.	122.	130.	137.	144.	151.	158.	165.	172.	178.	185.	10
30				103.	113.	123.	132.	141.	150.	158.	167.	175.	183.	191.	198.	206.	213.	3
32				118.	129.	140.	151.	161.	171.	181.	191.	200.	209.	218.	227.	235.	244.	6
34				134.	147.	159.	171.	183.	194.	205.	216.	227.	237.	247.	257.	267.	277.	8
36					165.	179.	193.	206.	219.	231.	244.	255.	267.	279.	290.	301.	312.	4
38					185.	201.	216.	231.	245.	259.	273.	286.	299.	312.	324.	337.	349.	4
40						223.	240.	257.	273.	288.	303.	318.	333.	347.	361.	375.	388.	2
42							266.	284.	302.	319.	336.	352.	368.	384.	399.	415.	430.	1
44							293.	313.	332.	351.	370.	388.	406.	423.	440.	457.	473.	3
46							322.	343.	365.	385.	406.	426.	445.	464.	483.	501.	519.	1
48							351.	375.	398.	421.	443.	465.	486.	507.	527.	547.	567.	1
50								408.	434.	458.	483.	506.	529.	552.	574.	596.	617.	-
52									471.	497.	524.	549.	574.	599.	623.	647.	670.	-
54										538.	566.	594.	621.	648.	674.	700.	725.	-
56										580.	611.	641.	670.	699.	727.	755.	782.	-
58											657.	689.	721.	752.	782.	812.	841.	-
60											705.	740.	773.	807.	839.	871.	902.	1
Trees	-	8	20	37	18	1	7	8	12	10	6	8	7	3	-	-	-	145

(See notes on reverse side)

Volume excludes bark and stump.
Stump heights measured from uphill side: 13" for 6" d.b.h., 15" for 8" d.b.h., 17" for 10" d.b.h., and 18" for 12" d.b.h. and larger.
Block indicates extent of basic data.
Form Class: Diameter inside bark at top of first 16.3-foot log divided by diameter outside bark at breast height, the result being multiplied by 100. Table on reverse side is for the average Form Class of the sample trees. Factors in the tabulation below are to be used to get volumes for other Form Classes.
The equations from which the tabled volumes were obtained are as follows: Logarithm cubic volume to 4 inches i.b. = 2.081,127 (logarithm d.b.h. in inches) + 0.691,137 (logarithm total height in feet) + 0.010,285 (form class) - 3.055,417.
Average deviation of individual tree volumes from values estimated by the equation is 6.6 percent.
Aggregate difference: Estimated values 0.01 percent high.

MULTIPLIERS FOR OTHER FORM CLASSES

Form class is 100 times d.i.b. top first log divided by d.b.h. o.b. Factors by which to multiply volumes in Form Class 70 table to obtain volumes for other form classes:

Form Class : (Tens) :	(Units) 0	1	2	3	4	5	6	7	8	9
5	0.62	0.64	0.65	0.67	0.68	0.70	0.72	0.74	0.75	0.77
6	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.98
7	1.00	1.02	1.05	1.07	1.10	1.13	1.15	1.18	1.21	1.24
8	1.27	1.30	1.33	1.36	1.39	1.43	1.46	1.50	1.53	1.57

Example: Volume of 36", 150-foot tree of form class 78 is 255 x 1.21 = 308.

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February 1950

Additional copies of this table may be obtained from the California Forest and Range Experiment Station, Box 245, Berkeley 1, California.